National Aeronautics and Space Administration

Report to the President

Actions to Implement the Recommendations

of The Presidential Commission on the Space Shuttle Challenger Accident

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DEDICATION

Those of us at NASA, who have worked incessantly since that day in January when the CHALLENGER and her crew, our friends, were lost, dedicate this report to those who will fly again into space in the future.

THE WHITE HOUSE

WASHINGTON

June 13, 1986

Dear Jim:

I have completed my review of the report from the Commission on the Space Shuttle CHALLENGER Accident. I believe that a program must be undertaken to implement its recommendations as soon as possible. The procedural and organizational changes suggested in the report will be essential to resuming effective and efficient Space Transportation System operations, and will be crucial in restoring U.S. space launch activities to full operational status.

Specifically, I would like NASA to report back to me in 30 days on how and when the Commission's recommendations will be implemented. This report should include milestones by which progress in the implementation process can be measured.

Let me emphasize, as I have so many times, that the men and women of NASA and the tasks they so ably perform are essential to the nation if we are to retain our leadership in the pursuit of technological and scientific progress.

Despite misfortunes and setbacks, we are determined to press on in our space programs. Again, Jim, we turn to you for leadership. You and the NASA team have our support and our blessings to do what has to be done to make our space program safe, reliable, and a source of pride to our nation and of benefit to all mankind.

I look forward to receiving your report on implementing the Commission's recommendations.

Sincerely,

Ronald Reagan

The Honorable James C. Fletcher
Administrator
National Aeronautics and
Space Administration
Washington, D.C. 20546

NASA
National Aeronautics and
Space Administration

Washington, D.C.
20546

Office of the Administrator

The President
The White House
Washington, DC 20500

Dear Mr. President:

I am pleased to submit the NASA plan to implement the recommendations of the Presidential Commission on the Space Shuttle Challenger Accident. The Commission has rendered the nation an exceptional service in conducting a comprehensive and thorough investigation. NASA agrees with the recommendations and is vigorously implementing them.

An overview of our efforts, the milestones by which we will measure our progress, and a detailed response to the specific Commission recommendations are provided in the enclosed report. A status report on our implementation program will be submitted in June 1987.

The men and women of NASA appreciate your continued personal support.

Respectfully,

James C. Fletcher
Administrator

Enclosure

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Executive Summary

On June 13, 1986, the President directed NASA to implement, as soon as possible, the recommendations of the Presidential Commission on the Space Shuttle Challenger Accident. The President requested that NASA report, within 30 days, how and when the recommendations will be implemented, including milestones by which progress can be measured.

In the months since the Challenger accident, the NASA team has spent many hours in support of the Presidential Commission on the Space Shuttle Challenger Accident and in planning for a return of the Shuttle to safe flight status. Chairman William P. Rogers and the other members of the Commission have rendered the Nation and NASA an exceptional service. The work of the Commission was extremely thorough and comprehensive. NASA agrees with the Commission's recommendations and is vigorously pursuing the actions required to implement and comply with them.

As a result of the efforts in support of the Commission, many of the actions required to safely return the Space Shuttle to flight status have been under way since March. On March 24, 1986, the Associate Administrator for Space Flight outlined a comprehensive strategy, and defined major actions, for safely returning to flight status. The March 24 memorandum (Appendix A) provided guidance on the following subjects:

- actions required prior to next flight,
- first flight/first year operations, and
- development of sustainable safe flight rate.

The Commission report was submitted to the President on June 9, 1986. Since that time, NASA has taken additional actions and provided direction required to comply with the Commission's recommendations (Appendix B). A summary of the key milestones is included at the end of the Executive Summary.

The NASA Administrator and the Associate Administrator for Space Flight will participate in the key management decisions required for implementing the Commission recommendations and for returning the Space Shuttle to flight status. NASA will report to the President on the status of the implementation program in June 1987.

The Commission report included nine recommendations, and a summary of the implementation status for each is provided:

Recommendation I

Solid Rocket Motor Design: On March 24, 1986, the Marshall Space Flight Center (MSFC) was directed to form a Solid Rocket Motor (SRM) joint redesign team to include participation from MSFC and other NASA centers as well as individuals from outside NASA. The team includes personnel from Johnson Space Center, Kennedy Space Center, Langley Research Center, industry, and the Astronaut Office. To assist the redesign team, an expert advisory panel was appointed which includes 12 people with six coming from outside NASA.

The team has evaluated several design alternatives, and analysis and testing are in progress to determine the preferred approaches which minimize hardware redesign. To ensure adequate program contingency in this effort, the redesign team will also develop, at least through concept definition, a totally new design which does not utilize existing hardware. The design verification and certification program will be emphasized and will include tests which duplicate the actual launch loads as closely as feasible and provide for tests over the full range of operating conditions. The verification effort includes a trade study which has been under way for several weeks to determine the preferred test orientation (vertical or horizontal) of the full-scale motor firings. The Solid Rocket Motor redesign and certification schedule is under review to fully understand and plan for the implementation of the design solutions as they are final-

ized and assessed. The schedule will be reassessed after the SRM Preliminary Design Review in September 1986. At this time it appears that the first launch will not occur prior to the first quarter of 1988.

Independent Oversight: In accordance with the Commission's recommendation, the National Research Council (NRC) has established an Independent Oversight Group chaired by Dr. H. Guyford Stever and reporting to the NASA Administrator. The NRC Oversight Group has been briefed on Shuttle system requirements, implementation, and control; Solid Rocket Motor background; and candidate modifications. The group has established a near-term plan that includes briefings and visits to review in-flight loads; assembly processing; redesign status; and other solid rocket motor designs, including the Titan. Longer term plans are being formulated by the group including participation in the Solid Rocket Motor preliminary design review in September 1986.

Recommendation II

Shuttle Management Structure: The Administrator has appointed General Sam Phillips, who served as Apollo Program Director, to study every aspect of how NASA manages its programs, including relationships between various field centers and NASA Headquarters. General Phillips has broad authority from the Administrator to explore every aspect of NASA organization, management and procedures. His activities will include a review of the Space Shuttle management structure.

On June 25, 1986, Astronaut Robert Crippen was directed to form a fact-finding group to assess the Space Shuttle management structure. The group will report recommendations to the Associate Administrator for Space Flight by August 15, 1986. Specifically, this group will address the roles and responsibilities of the Space Shuttle Program Manager to assure that the position has the authority commensurate with its responsibilities. In addition, roles and responsibilities at all levels of program management will be reviewed to specify the relationship between the program organization and the field center organizations. The results of this study will be reviewed with General Phillips and the Administrator with a decision on implementation of the recommendations by October 1, 1986.

Astronauts in Management: Rear Admiral Richard Truly, a former astronaut, has been appointed as Associate Administrator for the Office of Space Flight. Several active astronauts are currently serving in management positions in the agency. The Crippen group will address means to stimulate the transition of astronauts into other management positions. It will also determine the appropriate position for the Flight Crew Operations Directorate within the NASA organizational structure.

Shuttle Safety Panel: A Shuttle Safety Panel will be established by the Associate Administrator for Space Flight not later than September 1, 1986, with direct access to the Space Shuttle Program Manager. This date allows time to determine the structure and function of this panel, including an assessment of its relationship to the newly formed Office of Safety, Reliability, and Quality Assurance, and to the existing Aerospace Safety Advisory Panel.

Recommendation III

Critical Item Review and Hazard Analysis: On March 13, 1986, NASA initiated a complete review of all Space Shuttle program failure modes and effects analyses (FMEA's) and associated critical item lists (CIL's). Each Space Shuttle project element and associated prime contractor is conducting separate comprehensive reviews which will culminate in a program-wide review with the Space Shuttle Program Manager at Johnson Space Center later this year. Technical specialists from outside the Space Shuttle program have been assigned as formal members of each of these review teams. All Criticality 1 and 1R critical item waivers have been cancelled. The teams are required to reassess and resubmit waivers in categories recommended for continued program applicability. Items which cannot

be revalidated will be redesigned, qualified, and certified for flight. All Criticality 2 and 3 CIL's are being reviewed for reacceptance and proper categorization. This activity will culminate in a comprehensive final review with NASA Headquarters beginning in March 1987.

As recommended by the Commission, the National Research Council has agreed to form an Independent Audit Panel, reporting to the NASA Administrator, to verify the adequacy of this effort.

Recommendation IV

Safety Organization: The NASA Administrator announced the appointment of Mr. George A. Rodney to the position of Associate Administrator for Safety, Reliability, and Quality Assurance on July 8, 1986. The responsibilities of this office will include the oversight of safety, reliability, and quality assurance functions related to all NASA activities and programs and the implementation of a system for anomaly documentation and resolution to include a trend analysis program. One of the first activities to be undertaken by the new Associate Administrator will be an assessment of the resources including workforce required to ensure adequate execution of the safety organization functions. In addition, the new Associate Administrator will assure appropriate interfaces between the functions of the new safety organization and the Shuttle Safety Panel which will be established in response to the Commission Recommendation II.

Recommendation V

Improved Communications: On June 25, 1986, Astronaut Robert Crippen was directed to form a team to develop plans and recommended policies for the following:

- Implementation of effective management communications at all levels.
- Standardization of the imposition and removal of STS launch constraints and other operational constraints.
- Conduct of Flight Readiness Review and Mission Management Team meetings, including requirements for documentation and flight crew participation.

Since this recommendation is closely linked with the recommendation on Shuttle management structure, the study team will incorporate the plan for improved communications with that for management restructure.

This review of effective communications will consider the activities and information flow at NASA Headquarters and the field centers which support the Shuttle program. The study team will present findings and recommendations to the Associate Administrator for Space Flight by August 15, 1986.

Recommendation VI

Landing Safety: A Landing Safety Team has been established to review and implement the Commission's findings and recommendations on landing safety. All Shuttle hardware and systems are undergoing design reviews to insure compliance with the specifications and safety concerns. The tires, brakes, and nose wheel steering system are included in this activity, and funding for a new carbon brakes system has been approved. Runway surface tests and landing aid requirement reviews had been under way for some time prior to the accident and are continuing. Landing aid implementation will be complete by July 1987. The interim brake system will be delivered by August 1987. Improved methods of local weather forecasting and weather-related support are being developed. Until the Shuttle program has demonstrated satisfactory safety margins through high fidelity testing and during actual landings at Edwards Air Force Base, the Kennedy Space Center landing site will not be used for nominal end-of-mission landings. Dual Orbiter ferry capability has been an issue for some time and will be thoroughly considered during the upcoming months.

Recommendation VII

Launch Abort and Crew Escape: On April 7, 1986, NASA initiated a Shuttle Crew Egress and Escape review. The scope of this analysis includes egress and escape capabilities from launch through landing and will provide analyses, concepts, feasibility assess-

ments, cost, and schedules for pad abort, bailout, ejection systems, water landings, and powered flight separation. This review will specifically assess options for crew escape during controlled gliding flight and options for extending the intact abort flight envelope to include failure of 2 or 3 main engines during the early ascent phase. In conjunction with this activity, a Launch Abort Reassessment Team was established to review all launch and launch abort rules to ensure that launch commit criteria, flight rules, range safety systems and procedures, landing aids, runway configurations and lengths, performance versus abort exposure, abort and end-of-mission landing weights, runway surfaces, and other landing-related capabilities provide the proper margin of safety to the vehicle and crew. Crew escape and launch abort studies will be complete on October 1, 1986, with an implementation decision in December 1986.

Recommendation VIII

Flight Rate: In March 1986 NASA established a Flight Rate Capability Working Group. Two flight rate capability studies are under way: (1) a study of capabilities and constraints which govern the Shuttle processing flows at the Kennedy Space Center and (2) a study by the Johnson Space Center to assess the impact of flight specific crew training and software delivery/certification on flight rates. The working group will present flight rate recommendations to the Office of Space Flight by August 15, 1986. Other collateral studies are still in progress which address Presidential Commission recommendations related to spares provisioning, maintenance, and structural inspection. This effort will also consider the National Research Council independent review of flight rate which is under way as a result of a Congressional Subcommittee request.

NASA strongly supports a mixed fleet to satisfy launch requirements and actions to revitalize the United States expendable launch vehicle capabilities.

Additionally, a new cargo manifest policy is being formulated by NASA Headquarters which will establish manifest ground rules and impose constraints to late changes. Manifest control policy recommendations will be completed in November 1986.

Recommendation IX

Maintenance Safeguards: A Maintenance Safeguards Team has been established to develop a comprehensive plan for defining and implementing actions to comply with the Commission recommendations concerning maintenance activities. A Maintenance Plan is being prepared to ensure that uniform maintenance requirements are imposed on all elements of the Space Shuttle program. This plan will define the structure that will be used to document (1) hardware inspections and schedules, (2) planned maintenance activities, (3) maintenance procedures configuration control, and (4) maintenance logistics. The plan will also define organizational responsibilities, reporting, and control requirements for Space Shuttle maintenance activities. The maintenance plan will be completed by September 30, 1986.

A number of other activities are underway which will contribute to a return to safe flight and strengthening the NASA organization. A Space Shuttle Design Requirements Review Team headed by the Space Shuttle Systems Integration Office at Johnson Space Center has been assigned to review all Shuttle design requirements and associated technical verification. The team will focus on each Shuttle project element and on total Space Shuttle system design requirements. This activity will culminate in a Space Shuttle Incremental Design Certification Review approximately 3 months prior to the next Space Shuttle launch.

In consideration of the number, complexity, and interrelationships between the many activities leading to the next flight, the Space Shuttle Program Manager at Johnson Space Center has initiated a series of formal Program Management Reviews for the Space Shuttle program. These reviews are structured to be regular face-to-face discussions involving the managers of all major

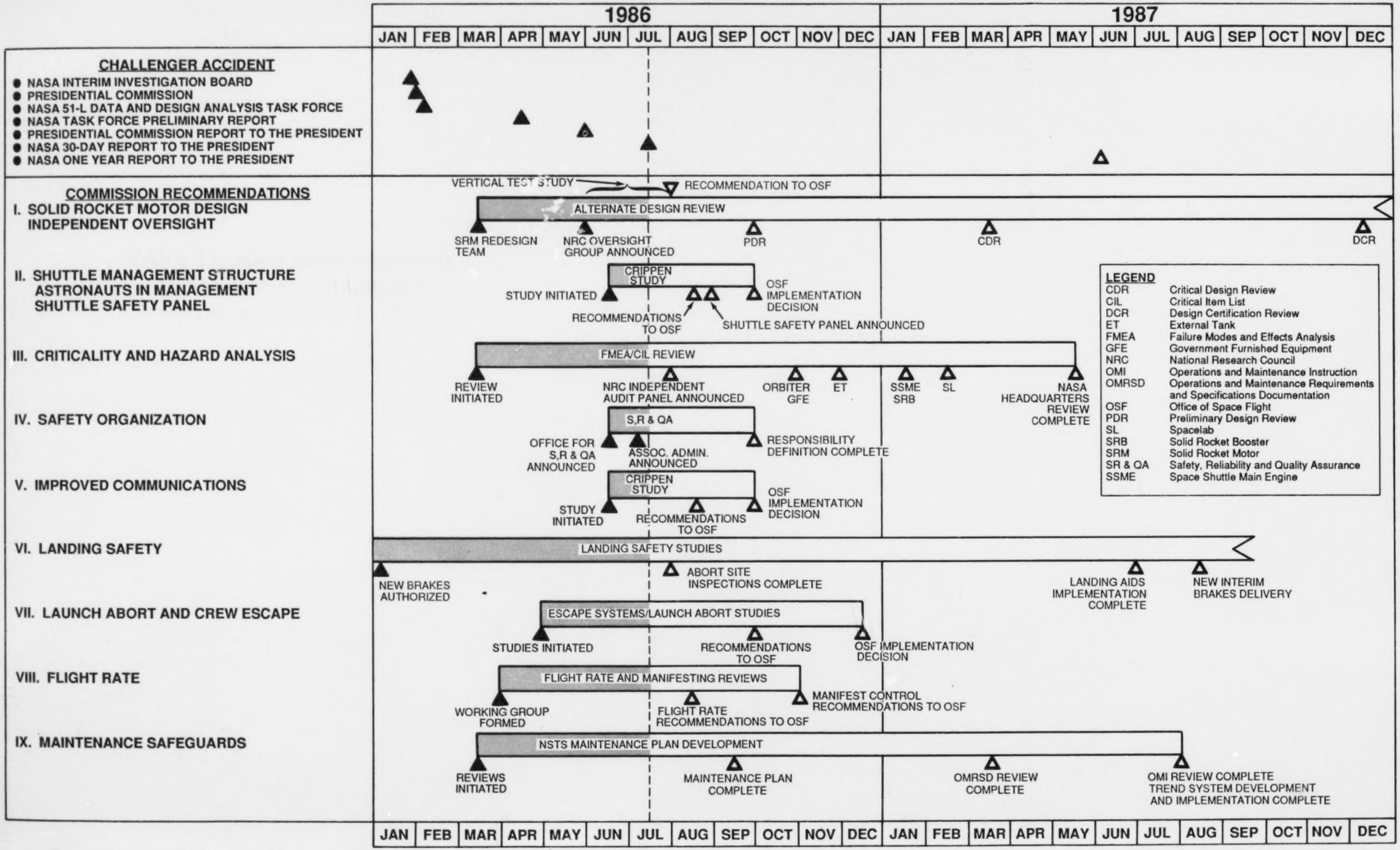
Space Shuttle program activities. Specific subjects to be discussed at each meeting will focus on progress, schedules, and actions associated with each of the major program review activities and will be tailored directly to current program activity for the time period involved. The first of these meetings was held at Marshall Space Flight Center on May 5-6, 1986, with the second at Kennedy Space Center on June 25, 1986. Follow-on reviews will be held approximately every 6 weeks. Results of these reviews will be reported to the Associate Administrator for Space Flight and to the NASA Administrator.

On June 19, 1986, the NASA Administrator announced termination of the development of the Centaur upper stage for use aboard the Space Shuttle. Use of the Centaur upper stage was planned for NASA planetary spacecraft launches as well as for certain national security satellite launches. Major safety reviews of the Centaur system were under way at the time of the Challenger accident, and these reviews were intensified in recent months to determine if the program should be continued. The final decision to terminate the Centaur stage for use with the Shuttle was made on the basis that even following certain modifications identified by the ongoing reviews, the resultant stage would not meet safety criteria being applied to other cargo or elements of the Space Shuttle system. NASA has initiated efforts to examine other launch vehicle alternatives for the major NASA planetary and scientific payloads which were scheduled to utilize the Centaur upper stage. NASA is providing assistance to the Department of Defense as it examines alternatives for those national security missions which had planned to use the Shuttle/Centaur.

The NASA Administrator has announced a number of Space Station organizational and management structural actions designed to strengthen technical and management capabilities in preparation for moving into the development phase of the Space Station program. The decision to create the new structure is the result of recommendations made to the Administrator by a committee, headed by General Phillips, which is conducting a long range assessment of NASA's overall capabilities and requirements.

Finally, NASA is developing plans for increased staffing in critical areas and is working closely with the Office of Personnel Management to develop a NASA specific proposal which would provide for needed changes to the NASA personnel management system to strengthen our ability to attract, retain, and motivate the quality work force required to conduct the NASA mission (Appendix C).

SPACE SHUTTLE RETURN TO FLIGHT



NASA Detailed Implementation of Presidential Commission Recommendations I - IX

PRESIDENTIAL COMMISSION ON THE SPACE SHUTTLE CHALLENGER ACCIDENT RECOMMENDATION

— I —

Design. The faulty Solid Rocket Motor joint and seal must be changed. This could be a new design eliminating the joint or a redesign of the current joint and seal. No design options should be prematurely precluded because of schedule, cost or reliance on existing hardware. All Solid Rocket Motor joints should satisfy the following requirements:

- The joints should be fully understood, tested and verified.
- The integrity of the structure and of the seals of all joints should be not less than that of the case walls throughout the design envelope.
- The integrity of the joints should be insensitive to:
  - Dimensional tolerances.
  - Transportation and handling.
  - Assembly procedures.
  - Inspection and test procedures.
  - Environmental effects.
  - Internal case operating pressure.
  - Recovery and reuse effects.
  - Flight and water impact loads.
- The certification of the new design should include:
  - Tests which duplicate the actual launch configuration as closely as possible.
  - Tests over the full range of operating conditions, including temperature.
- Full consideration should be given to conducting static firings of the exact flight configuration in a vertical attitude.

Independent Oversight. The Administrator of NASA should request the National Research Council to form an independent Solid Rocket Motor design oversight committee to implement the Commission's design recommendations and oversee the design effort. This committee should:

- Review and evaluate certification requirements.
- Provide technical oversight of the design, test program and certification.
- Report to the Administrator of NASA on the adequacy of the design and make appropriate recommendations.

NASA has formed a Solid Rocket Motor (SRM) Joint Redesign team at the Marshall Space Flight Center. This team includes personnel from several NASA Centers, industry, and the Astronaut Office. Their activities are being reviewed by a NASA/industry advisory panel and an Independent Oversight Group from the National Research Council.

The team has evaluated several design alternatives, and analysis and testing is in progress to determine the preferred approaches which minimize hardware redesign. In addition, an approach will be developed, at least through concept definition, for a new design which does not utilize existing hardware. The primary selection criteria will be development of an SRM joint design that is safe to fly. A secondary objective is to minimize schedule impact by use of existing hardware, if that can be done without compromising safety.

Analysis and testing is being performed to support the design selection process and to ensure the adequacy of the verification and certification of the redesigned joint. The static test orientation and configuration is being analyzed, and a proposed method is scheduled to be selected in July 1986. The Solid Rocket Motor redesign and certification schedule is under review to fully understand and plan for the implementation of the design solutions as they are finalized and assessed.

NASA Implementation of Recommendation I

On March 24, 1986, the Marshall Space Flight Center was directed to form a Solid Rocket Motor Redesign Team to include participation from Marshall, other NASA Centers, and the Astronaut Office, as well as individuals from outside NASA. To assist the redesign team, an expert advisory panel was appointed which includes 12 people, with six coming from outside NASA. The redesign team was directed to review the Commission findings and recommendations and develop a plan to provide a Solid Rocket Motor that addresses all the criteria in the Commission recommendations. The primary objective of the redesign effort is to provide a Solid Rocket Motor with field and nozzle joints that is safe to fly. A secondary objective will be to minimize the schedule impact by using existing hardware, if this can be done without compromising safety. To ensure adequate program contingency in this effort, the redesign group will also develop, at least through concept definition, a totally new design that does not utilize existing hardware. Key program milestones have been established. Emphasis is being placed on the verification effort to ensure its adequacy. As one part of the verification plan, a trade study is being conducted between vertical (nozzle up and down) and horizontal static tests to determine the preferred test firing orientation.

At the request of the NASA Administrator, the National Research Council (NRC) has established an Independent Oversight Group chaired by Dr. H. Guyford Stever and reporting directly to the Administrator. The NRC Oversight Group has been briefed on Shuttle system requirements, implementation, and control; Solid Rocket Motor background; and candidate modifications. The group has established a near-term plan that includes briefings and visits to review in-flight loads, assembly processing, redesign status, and other solid rocket motor designs, including the Titan. Longer term plans of the group are being formulated.

Many design alternatives have been evaluated, analyses and tests have been conducted, initial verification plans have been established, and overall schedules have been developed. In parallel, major SRM subassemblies and many critical processes have been reassessed, and efforts to determine those requiring additional review or modifications are in varying stages of maturity.

The team has evaluated several design alternatives and is conducting analyses and testing to determine the best approach which will utilize either existing hardware or modification of that in the production flow. An alternate joint design that does not utilize existing hardware is also under way. Additional design and studies are considering modifications to ground support equipment to resolve transportation, handling, and assembly difficulties encountered in the past, as well as ground and flight systems to compensate for the environmental effects of temperature and inclement weather. Other design modifications to reduce criticality or to resolve prior difficulties relating to the ignition system, factory joints, and nozzle are being considered. Design solutions for these modifications have been identified, and programmatic assessments are being finalized.

Analyses and tests have been performed to support design selection. The analyses relate to structural strength, dimensional tolerances, gas and thermal dynamics, elastomeric material behavior, and leak check adequacy. Tests being conducted range from small scale cold gas O-ring performance tests, to 70 pound motor hot gas insulation evaluation, to full size joint mating tests evaluating assembly aids. Further, thoroughly comprehensive analyses are under way and planned that will be test-verified to fully understand the joint operation. The total verification program comprises analyses and an extensive test program using subscale fixtures, full-size mated segments subjected to hot gas transient motor pressure, full-size segment assembly demonstrations, and four full scale static hot firing tests that will be either horizontal, vertical, or a combination of both. The static test orientation is being fully explored, and the preferred configuration is

anticipated to be proposed in late July 1986. Two of these full-scale tests will contain all system changes.

The Solid Rocket Motor design schedule is currently under review to fully understand and plan for the implementation of the design solutions as they are finalized and assessed. The schedule will be reassessed after the Preliminary Design Review in September 1986.

PRESIDENTIAL COMMISSION ON THE SPACE SHUTTLE CHALLENGER ACCIDENT RECOMMENDATION

— II —

Shuttle Management Structure. The Shuttle Program Structure should be reviewed. The project managers for the various elements of the Shuttle program felt more accountable to their center management than to the Shuttle program organization. Shuttle element funding, work package definition, and vital program information frequently bypass the National STS (Shuttle) Program Manager.

A redefinition of the Program Manager's responsibility is essential. This redefinition should give the Program Manager the requisite authority for all ongoing STS operations. Program funding and all Shuttle Program work at the centers should be placed clearly under the Program Manager's authority.

Astronauts in Management. The Commission observes that there appears to be a departure from the philosophy of the 1960s and 1970s relating to the use of astronauts in management positions. These individuals brought to their positions flight experience and a keen appreciation of operations and flight safety.

- NASA should encourage the transition of qualified astronauts into agency management positions.
- The function of the Flight Crew Operations director should be elevated in the NASA organization structure.

Shuttle Safety Panel. NASA should establish an STS Safety Advisory Panel reporting to the STS Program Manager. The charter of this panel should include Shuttle operational issues, launch commit criteria, flight rules, flight readiness and risk management. The panel should include representation from the safety organization, mission operations, and the astronaut office.

NASA is reviewing all aspects of its management structure. The Administrator requested General Sam Phillips to return to NASA and review all aspects of the organizational management structure and procedural activities. This activity is currently in process and is expected to continue for several months.

Astronaut Robert Crippen is leading a study addressing the STS management structure and the roles of astronauts in that structure. Specifically, the primary objective of the study is to strengthen the programmatic authority of STS management, and to clearly define the roles and responsibilities between the STS program and the NASA field centers. In addition, ways of encouraging astronauts to assume management positions will be identified as well as assessing their respective positions in the overall organizational structure. The results of this study will be thoroughly reviewed with General Phillips prior to incorporating the recommendations.

A Shuttle Safety Panel with direct access to the Associate Administrator for Space Flight as well as the NSTS Program Manager will be established by September 1, 1986. The exact structure of this group and its relationship with other NASA safety organizations is currently under study.

NASA Implementation of Recommendation II

NASA Administrator

NASA Administrator Dr. James C. Fletcher has appointed General Sam Phillips, who served as Apollo Program Director, to study every aspect of how NASA manages its programs, including relationships between the various centers and NASA Headquarters. General Phillips' review is not limited to the Challenger accident and operates with broad authority from the Administrator to examine all aspects of NASA's organization, management, and procedural activities. He will provide his findings and recommendations to the Administrator by the end of 1986.

Associate Administrator for Space Flight

On June 25, 1986, Astronaut Robert Crippen was directed to form a fact-finding group to assess the National Space Transportation System (NSTS) management structure including the Shuttle Program Manager's responsibilities, use of astronauts in management positions, and the functional location of the Flight Crew Operations Director in the organizational structure.

The fact-finding group consists of:

Robert Crippen, Group Leader
Richard Kohrs, Deputy Manager, NSTS Office
Walter Williams, Special Assistant to the NASA Administrator
George Page, LSOC, Director of STS Test Operations, Vandenberg Launch Site

This group is supplemented by individuals representing each of the field center institutions reporting to the Office of Space Flight:

Andrew Pickett, Kennedy Space Center
William Sneed, Marshall Space Flight Center
Clifford Charlesworth, Johnson Space Center
Roy Estess, National Space Technology Laboratories

The group is interviewing individuals at various management levels representing the STS program, the field center institutions, NASA Headquarters, and the major Shuttle contractors. In addition, the group will interview former senior program officials to gain their perspective from past program experience. Finally, the group will review the findings and proposals with a private consulting firm that is recognized as knowledgeable in management techniques.

As of this time, the group has completed interviews at the Marshall and Kennedy Space Flight Centers, with subsequent interview trips scheduled to the Johnson Space Center and various contractor locations. Presentations of findings and recommendations from this study will be presented to the Associate Administrator for Space Flight by August 15, 1986. The findings and recommendations will then be reviewed with the Administrator to insure that they are consistent with the overall recommendations being developed by General Phillips. The Office of Space Flight will then implement the recommendations as appropriate.

Specifically, the Level I/II/III program management concept will be reevaluated with changes implemented to strengthen the structure and to reduce the potential for conflict between the program organization and the NASA institutional organizations. In accordance with the Commission recommendations, strong consideration will be given to placing all Shuttle program funding and work at the centers under the Program Manager's authority.

In addition, means to implement the recommended use of astronauts in management positions will be identified. There are astronauts or former astronauts in ten management positions in the agency at this time, including the Associate Administrator for Space Flight. This brings the number of astronauts who have been included in management positions during the Shuttle program to approximately thirty, of which half have been in positions outside the Flight Crew Operations Directorate. This process is expected to continue and to be strengthened as the program management is restructured after this review.

The Associate Administrator for Space Flight will form a Shuttle Safety Panel by September 1, 1986. This panel will have direct access to the Associate Administrator for Space Flight and to the NSTS Program Manager. A detailed study to define the roles and responsibilities and the staffing of this panel is currently under way. In particular, the relationship to the newly formed Office of Safety, Reliability, and Quality Assurance, as well as the independent Aerospace Safety Advisory Panel, must be assessed.

PRESIDENTIAL COMMISSION ON THE SPACE SHUTTLE CHALLENGER ACCIDENT RECOMMENDATION

— III —

Criticality Review and Hazard Analysis. NASA and the primary Shuttle contractors should review all Criticality 1, 1R, 2, and 2R items and hazard analyses. This review should identify those items that must be improved prior to flight to ensure mission success and flight safety. An Audit Panel, appointed by the National Research Council, should verify the adequacy of the effort and report directly to the Administrator of NASA.

NASA has initiated a review of all Space Shuttle Program Failure Modes and Effects Analyses, Critical Item Lists, and Hazard Analyses. Each Space Shuttle project element and its prime contractors are conducting independent reviews which will be integrated and assessed by the element project office. The results of these reviews and recommended actions will be provided to the NSTS Program Manager and to the Associate Administrator for Space Flight for final resolution. Technical specialists from outside the Space Shuttle program are assigned as formal members of each review team. The teams are reassessing all Criticality 1, 1R, 2, 2R, and 3 items. All Criticality 1 and 1R critical item waivers have been cancelled and must be resubmitted for approval after these reviews. The National Research Council has agreed to establish an Audit Panel to verify the adequacy of this effort and to report to the NASA Administrator on its findings.

NASA Implementation of Recommendation III

All STS project offices and element contractors are required to review their hardware design to identify those systems or components which if they fail could present a risk to the safety of the crew or could result in loss of the vehicle or mission. This is accomplished through a process defined in NASA Handbook 5300.4 and which requires the project to perform a Failure Modes and Effects Analysis (FMEA) and to develop a Critical Item List (CIL) and Hazard Analysis (HA) for each element. The purpose of the FMEA is to identify the various potential failure modes of the flight element components and assess the effects on the specific flight element as well as the total launch vehicle and mission. The potential failure modes are derived from analyses of function, design, and related manufacturing processes. The CIL identifies the critical failure modes and the rationale for retention. The items contained in the CIL are classified in five major categories commensurate with the degree of criticality. The five classifications of the CIL are as follows:

1 — Loss of life or vehicle
1R — Failure of both redundant hardware elements could cause loss of life or vehicle
2 — Loss of mission
2R — Failure of both redundant hardware elements could cause loss of mission
3 — All others

The Hazard Analysis identifies the hazards and their status of resolution and categorizes them as controlled (by design, procedure, etc.) or as an accepted risk. This review process was conducted during the development phase of the STS program prior to the first flight and FMEA's, CIL's, and HA's existed at the time of the 51-L launch.

The Commission recommended that a reassessment of the FMEA/CIL, in conjunction with the hazard analyses, be conducted to assure that Criticality 1, 1R, 2, and 2R items are reevaluated and that the hazard analyses properly identify the Criticality 1 items. Thus, the associated risks and hazards will be thoroughly understood and appropriate action can be taken to minimize their criticality. NASA accepts this recommendation and the review is under way.

The review was initiated by a March 13, 1986, letter from the NSTS Program Manager to all project elements requesting that each office review its CIL's and FMEA's. The purpose of the review is to affirm the completeness and accuracy of each FMEA/CIL for the current NSTS design. The March 24, 1986, memorandum from the Associate Administrator for Space Flight defining the strategy for safely returning the Space Shuttle to flight status, directed that Criticality 1 and 1R items be subjected to a total review with a complete reapproval process implemented and that those items which were not revalidated must be redesigned, certified, and qualified for flight. The memorandum also directed that all Criticality 2 and 3 CIL's be reviewed for reacceptance and proper categorization. On March 28, 1986, the NSTS Manager signed Program Directive S40019 which directed that all Criticality 1, 1R, and payload safety waivers be reverified, signed, and resubmitted for approval.

Following this direction, teams for each NSTS element project office (Level III), including the Solid Rocket Booster (SRB), External Tank (ET), Space Shuttle Main Engine (SSME), Orbiter, Government Furnished Equipment (GFE), Spacelab (SL), Kennedy Space Center (KSC), and Vandenburg Launch Site (VLS), have been formed and are reviewing the FMEA's, CIL's, and HA's which apply to their element hardware to assure that:

a. The failure modes, causes, and related effects are identified and documented.
b. The criticality has been properly assigned.
c. The retention rationale for each critical item is complete and accurate.

The reviews are being conducted by technical teams at the appropriate NASA centers and the element prime contractors. The results of both reevaluations will be presented

to a Level III Configuration Control Board (CCB) Preboard which will review all NASA and contractor items and select those which require submittal to the Level III CCB for approval. The preboard will also review and recommend enhancements such as design and process changes, instrumentation and software additions, and testing or checkout changes which could be implemented to eliminate critical failure modes, reduce criticality, or minimize the possibility of failure or the effect of the failure. The preboard will select those items which should be submitted to the Level III CCB for review. The preboard membership will consist of, at a mimimum, the following members:

a. NASA engineering management representative
b. Safety representative
c. Reliability representative
d. Astronaut Office representative
e. Outside representative (not affiliated with the NSTS).

In addition to these project level reviews, selected independent contractors will review the ET, Orbiter, SRB, and SSME FMEA/CIL's and provide their assessment to the project manager.

The Level III CCB will review the preboard data and submit those significant items, including proposed enhancements, to the Level II Program Requirements Change Board (PRCB) for consideration by the NSTS Program Manager.

The element interface functional analysis is being reevaluated by the Systems Integration contractor. After this systems integration review, the results will be coordinated with the ET, Orbiter, SRB, and SSME Project Offices, and the coordinated results submitted to the Level II Systems Integration Review Board. The results will then be presented to the Level II PRCB for approval.

The Level II PRCB, including membership from the Aerospace Safety Advisory Panel, will review the Level III CCB significant items, CIL changes, and enhancement recommendations. The Level II PRCB may audit the enhancements not selected by Level III. The Level II PRCB will review and recommend any CIL changes and enhancements to Level I NASA Headquarters for approval. A summary of disapproved CIL changes and enhancements will also be documented and provided to Level I.

To assist in this process, the NSTS Program Manager has instituted a Level II Overview Group to assure that prime contractor reviews are consistent and conform to the Level II FMEA/CIL reevaluation plan. The ET contractor, Martin Marietta Corporation (MMC) at Michoud, was visited on June 16-20, 1986, with satisfactory results. The Orbiter contractor, Rockwell International (RI) at Downey, CA, will be visited the week of July 14, 1986. Rocketdyne, Thiokol, United Space Boosters Inc. (USBI), and other prime contractors, will be visited in the following weeks.

The Level II results and recommendations will be reviewed by Level I. The Level I board will be chaired by the NASA Associate Administrator for Space Flight and consist of his designated representatives. Level I will approve all items on the revalidated Criticality 1 and 1R CIL lists.

The overall reevaluation is planned to occur incrementally and is scheduled to continue through mid-1987. Each project manager will forward the results of their integrated review through the management approval cycle as each subsystem is completed. Safety engineering will present the results of the hazard analysis reevaluation to the Level III CCB, the Senior Safety Review Board, the Level II PRCB for approval, and NASA Headquarters for review.

The Commission recommended that the National Research Council (NCR) appoint an Audit Panel to verify the adequacy of this effort and report directly to the Administrator of NASA. This request has been made by NASA and accepted by the NRC. The NRC is forming the panel and NASA will support them as required.

PRESIDENTIAL COMMISSION ON THE SPACE SHUTTLE CHALLENGER ACCIDENT RECOMMENDATION

— IV —

Safety Organization. NASA should establish an Office of Safety, Reliability and Quality Assurance to be headed by an Associate Administrator, reporting directly to the NASA Administrator. It would have direct authority for safety, reliability, and quality assurance throughout the agency. The office should be assigned the work force to ensure adequate oversight of its functions and should be independent of other NASA functional and program responsibilities.

The responsibilities of this office should include:

- The safety, reliability and quality assurance functions as they relate to all NASA activities and programs.
- Direction of reporting and documentation of problems, problem resolution and trends associated with flight safety.

On July 8, 1986, NASA Administrator Dr. James C. Fletcher announced the appointment of Mr. George A. Rodney to the position of Associate Administrator for Safety, Reliability, and Quality Assurance. In this position Mr. Rodney will have overall responsibility for development and oversight of all Safety, Reliability, and Quality Assurance functions within NASA. In addition, he will assume the responsibility of implementing a system for anomaly documentation and resolution to include a trend analysis program.

NASA Implementation of Recommendation IV

A NASA Office of Safety, Reliability, and Quality Assurance (SR&QA) headed by an Associate Administrator and reporting directly to the NASA Administrator has been established. This position will be responsible for the oversight of safety, reliability, and quality assurance functions related to all NASA activities and programs. In addition, it will be responsible for the direction of reporting and documentation of problems, problem resolution, and trends associated with safety.

Specifically, this office will be responsible for:

a. Establishment and implementation of agency SR&QA policies, plans, and procedures.
b. Insuring that risks are minimized by engineering design and operating procedures.
c. Investigation of and reporting on all NASA mishaps, incidents, and accidents.
d. Implementing a trend analysis program that includes accurate reporting of anomalies, analysis and testing of problems, and implementation of corrective measures.
e. Ensuring that SR&QA issues are fully considered at all design, flight, and test readiness reviews.
f. Ensuring that all NASA SR&QA organizations are adequately staffed with qualified personnel.
g. Maintaining an effective dynamic safety program.
h. Providing an integrated focus for agencywide program assurance policies.

PRESIDENTIAL COMMISSION ON THE SPACE SHUTTLE CHALLENGER ACCIDENT RECOMMENDATION

— V —

Improved Communications. The Commission found that Marshall Space Flight Center project managers, because of a tendency at Marshall to management isolation, failed to provide full and timely information bearing on the safety of flight 51-L to other vital elements of Shuttle program management.

- NASA should take energetic steps to eliminate this tendency at Marshall Space Flight Center, whether by changes of personnel, organization, indoctrination or all three.
- A policy should be developed which governs the imposition and removal of Shuttle launch constraints.
- Flight Readiness Reviews and Mission Management Team meetings should be recorded.
- The flight crew commander, or a designated representative, should attend the Flight Readiness Review, participate in acceptance of the vehicle for flight, and certify that the crew is properly prepared for flight.

NASA is reviewing this recommendation as part of the review of the program management structure (Presidential Commission Recommendation II). The results of this activity will be presented to the Associate Administrator for Space Flight by August 15, 1986.

NASA Implementation of Recommendation V

On June 25, 1986, Astronaut Robert Crippen was directed to form a team to develop plans and policies for the following:

1. Implementation of effective management communication at all levels.

2. Standardization of the imposition and removal of STS launch constraints and other operational constraints.

3. Conduct of Flight Readiness Review and Mission Management Team meetings, including requirements for documentation and flight crew participation.

Because this recommendation is closely linked with Recommendation II, the study team will incorporate its plan for improved communications with that for the Shuttle management review. An integrated presentation of recommendations will be given to the Associate Administrator for Space Flight by August 15, 1986.

PRESIDENTIAL COMMISSION ON THE SPACE SHUTTLE CHALLENGER ACCIDENT RECOMMENDATION

— VI —

Landing Safety. NASA must take actions to improve landing safety.

- The tire, brake and nosewheel steering systems must be improved. These systems do not have sufficient safety margin, particularly at abort landing sites.
- The specific conditions under which planned landings at Kennedy would be acceptable should be determined. Criteria must be established for tires, brakes and nosewheel steering. Until the systems meet those criteria in high fidelity testing that is verified at Edwards, landing at Kennedy should not be planned.
- Committing to a specific landing site requires that landing area weather be forecast more than an hour in advance. During unpredictable weather periods at Kennedy, program officials should plan on Edwards landings. Increased landings at Edwards may necessitate a dual ferry capability.

NASA has established a Landing Safety Team to develop an implementation plan to comply with the Commission recommendation. Some improvements to the brakes and nosewheel steering systems had been made and other changes were under way prior to the accident. These planned improvements are being reassessed and additional changes are under consideration. Tire, brake, and runway surface tests are being conducted, and a plan to standardize landing aids and to install arresting barriers at all runways has been developed. An improved weather forecasting and reporting capability is being developed which will enhance the forecasting of weather in support of launch and landing decisions. Planned end of mission landings at the Kennedy Space Center will occur only after adequate safety margins have been demonstrated by test and by landings at Edwards Air Force Base.

NASA Implementation of Recommendation VI

The NSTS Program Manager established a Landing Safety Team to review the Commission findings and recommendations on landing safety and to develop an implementation plan to comply with the Commission recommendations. This effort will include:

a. Identification of improvements required in tire, brake, nosewheel steering, and other landing systems to assure safe operation;
b. Development of a plan to implement the required improvements and to certify the overall landing system;
c. Determination of landing criteria for all potential landing sites, nominal and contingency;
d. Documentation of landing weather criteria for each site, taking local and seasonal variability and unpredictability into account.

Until the program has demonstrated satisfactory safety margins through high fidelity testing and during actual landings at Edwards Air Force Base, the Kennedy landing site will not be used for nominal end-of-mission landings.

Two brake improvement programs, a tire improvement study, a runway surface study and other hardware-related studies are under way. Design activities to improve the redundancy of the nosewheel steering system have been initiated. A plan to provide standard landing aids and other facilities including arresting barriers at all runways is being developed. An improved weather reporting capability is being developed which will enhance the weather forecasting in support of launch and landing decisions.

The two brake improvement programs currently under way include: an interim energy capability improvement to be implemented by first flight and a longer term carbon brake development program. The interim modification includes addition of six hydraulic system orifices, an improved brake wear-in procedure, and a stiffer axle to correct the dynamic oscillation phenomenon seen on early flights. Also included are a pressure balance feature to evenly distribute the energy load between inboard and outboard brakes and a thicker stator which promises to improve energy absorption capability. The long-term carbon brake program is planned to increase energy absorption capability by 80-100%.

The objective of the tire improvement study and runway surface study is to determine how best to decrease the tire wear experienced during previous KSC landings and to improve crosswind landing capability. Additionally, tests are planned at Wright Patterson AFB to improve the ability to mathematically model tire side force characteristics in support of upcoming simulations.

A major upgrade of the nosewheel steering system was accomplished prior to the STS 61-A flight. The system to date has demonstrated improved handling qualities but it is still characterized by several single point failure modes. Two design activities are under way to improve redundancy: fail operational fail-safe avionics with the current single string hydraulic system and total fail-operational fail-safe nosewheel steering (including hydraulics). Either system will require substantial software changes and pilot in-the-loop simulations for verification prior to flight test. Other hardware related studies in progress include tire blowout protection, autobraking, tire pressure instrumentation, and anti-skid improvements.

A thorough review (including climatological statistics) of the available runways in Europe and Africa has been accomplished to assist in evaluating those runways which can improve Trans-Atlantic Abort Landing (TAL) safety margins. A site survey team will look at four Moroccan runways in July. The findings of this team will be used to finalize the selection of a site and implement recommended improvements.

In addition, a plan to provide standard landing aids and other facilities at all runways has been adopted. This plan includes the procurement of arresting barriers to provide safe stops in the event of brake failures or unforecast wet runway conditions. A minimum weather reporting capability is

being developed which should ensure acceptable weather for abort and end of mission landings.

The flight rules which govern the use of all landing sites, for both nominal and contingency situations, are being reevaluated. Differences in flight rules between nominal end-of-mission and abort landings may be necessary because of facility deficiencies at some abort landing sites; however, safety will not be significantly affected. This landing safety review process is an ongoing activity which will be refined as planned capabilities are implemented.

Providing a dual Shuttle Carrier Aircraft (SCA) capability for the Orbiter has been a programmatic issue for some time. The plans for use of Edwards Air Force Base as the landing site until landing safety margins are improved, will increase the need for a dual ferry capability. This issue will be thoroughly considered during the upcoming months.

PRESIDENTIAL COMMISSION ON THE SPACE SHUTTLE CHALLENGER ACCIDENT RECOMMENDATION

— VII —

Launch Abort and Crew Escape. The Shuttle program management considered first-stage abort options and crew escape options several times during the history of the program, but because of limited utility, technical infeasibility, or program cost and schedule, no systems were implemented. The Commission recommends that NASA:

- Make all efforts to provide a crew escape system for use during controlled gliding flight.
- Make every effort to increase the range of flight conditions under which an emergency runway landing can be successfully conducted in the event that two or three main engines fail early in ascent.

NASA has initiated a review of the STS Crew Egress/Escape and launch abort capability. The crew Egress/Escape analysis is considering concepts for the total mission profile which includes pad activities, launch through flight to orbit, and descent from orbit to landing. To analyze each aspect of the mission, design teams for ground egress, bail-out ejection systems, water landings, and powered flight separation have been established, as well as a systems engineering team to maintain study continuity and integrate the results of the proposed systems concepts. In conjunction with the systems engineering team, an envelope definition team is providing the appropriate trajectories to be used by each team. The trajectories are being overlaid with the physiological envelope limits of the crew; the combined trajectory and physiological envelope are being evaluated against the capabilities of the various system concepts. From the data and preliminary analysis, the concepts determined to be most feasible will get further study. The teams will consider modifications to existing STS hardware and concepts which may be included in future vehicle designs.

A launch abort assessment team has been established to review all aspects of the abort options available during the launch phase. This team is reviewing the abort mode software implementation, procedures, and navigation targeting as well as the groundrules and constraints that are used during the design of the ascent trajectory. This team is reviewing all aspects of the launch process to assure that when operations resume, they are as safe as possible and maximize the opportunity for achieving an emergency runway landing during launch phase aborts.

NASA Implementation of Recommendation VII

STS Crew Egress and Escape System. The NSTS Program Manager initiated a study effort in April of this year to consider all aspects of atmospheric crew escape from the time of crew ingress on the pad to post landing Orbiter egress. This study is being conducted by a team led by the Johnson Space Center Engineering Directorate with support from the Astronaut Office. Inputs have been solicited and received from escape experts from the Navy and the Air Force as well as the Langley Research Center and the Kennedy Space Center. The team is reviewing past studies as well as new and innovative concepts. A review of the design ground rules confirmed that the Shuttle was designed for intact (runway landing) abort for the case of loss of thrust in one main engine. These analysis requirements have been expanded to include two and three engine out cases. The number of crew that each concept could safely extract and the crew survival requirements will be identified. The Crew Escape study will be completed on October 1, 1986, with an implementation decision in December 1986.

The current escape mode for other than intact abort is ditching. This study is emphasizing creation of an alternative to ditching and to expanding the escape envelope. The study team will identify the maximum altitude of escape coverage for ascent, abort, and entry for each individual concept under consideration. Thermal protection, oxygen, and pressure suit requirements will be identified for the concepts covering the higher altitudes.

The study effort is divided into teams covering first stage powered ascent, ejection systems, bailout, ditching, and ground egress. Consistent envelopes and costing techniques are being used to insure uniform assessment. Each team has derived several concepts and assessed the advantages, disadvantages, cost, and vehicle changes associated with each.

The preliminary conclusions resulting from the study are as follows:

- No concept provides complete coverage of the flight envelope.
- Low-cost options provide less envelope coverage.
- More costly concepts severely impact performance capability due to additional weight.
- Ditching is unpredictable and life threatening and should be avoided, if possible.

The preliminary recommendations of the study team are as follows:

- Initiate a study of manual and powered extraction bailout. Design goals should be early implementation, minimum weight, and maximum crew size.
- Initiate a long-range study for combinations of ejection seats and passenger compartments.
- Continue ditching structural integrity studies and initiate crew simulation training for ditching.
- Initiate a detailed feasibility study of aeroseparation during first stage (prior to SRB separation) flight.
- Flame protection should be provided for the launch pad access area, the hazardous gas detection system should be reviewed, and TV coverage of the total crew egress route should be provided.
- Reanalyze the slide system from platform to basket to bunker to transport vehicle.
- Augment Orbiter post landing egress capability with a slide.
- Assign a pad egress safety manager with overall pad egress safety responsibility.

The preliminary recommendations are being reviewed at this time, and hardware contractors will be requested to provide study plans, design proposals, and funding requirements for review by the NSTS Program Office prior to any final implementation decision.

Launch/Abort Reassessment. A Launch/Abort Reassessment Team was formed to perform a total review of the launch phase and abort options available within that phase. This team will insure that all available options to

provide emergency runway landing capability are defined. These options will then be reviewed by the NSTS Program Manager prior to any implementation decisions being made.

This team has been formed and is divided into subgroups. These sub-groups and their work are described in subsequent paragraphs. The initial thrust of this team has been directed toward those long-lead decisions required for the first flight; namely, an evaluation of the Trans-Atlantic Abort mode, participation in the flight design process, and a review of the required flight software changes. The flight design baseline is now complete, and a report citing the acceptability of the Trans-Atlantic Abort mode has been provided to the Program Manager.

The Abort Mode Implementation subgroup has focused on the first flight activities. This group is reviewing the final submittal of flight software modifications, the certification history of the ascent abort modes, the verification process for both onboard and ground software, contingency procedures, and abort targeting.

The Ascent Design subgroup is reviewing the ground rules and constraints that are used to shape the ascent trajectory, as well as the methods of predicting ascent performance margin. Flight product development processes and the verification of these products are also being reviewed. The techniques and procedures for assuring the ability of the vehicle to perform in the ascent environment, as it is observed to exist on launch day, will also be assessed.

The Systems Management subgroup is reviewing all vehicle systems and their operational management. Issues uncovered during these review sessions are being resolved by the group, where possible, and, when required, issues are fowarded to the appropriate level of management. Changes are being made to vehicle requirements, ground and flight documentation, flight rules, flight software, and where necessary, flight hardware changes are being proposed.

The Range Safety subgroup, which also includes Air Force personnel, will assure the adequacy of the tools, procedures, and rules for developing the proper blend of flight and ground safety during the ascent phase. The group is reviewing the Space Shuttle range safety hardware to evaluate the need for carrying destruct charges on both the External Tank and Solid Rocket Boosters.

Other subgroups of this team are reviewing weather statistics and forecasting tools and techniques as they pertain to launch and landing operations. The process of implementing flight software products to meet flight requirements is also being reviewed. The Launch Commit Criteria and Flight Rule review groups have begun a systematic review of the decision making criteria used to commit a vehicle to launch and to govern the decision making processes used in flight.

This Launch/Abort Reassessment Team will review every aspect of the launch process and assure that when operations resume, they are as safe as possible. The Launch/Abort study will be complete on October 1, 1986, with an implementation decision in December 1986.

PRESIDENTIAL COMMISSION ON THE SPACE SHUTTLE CHALLENGER ACCIDENT RECOMMENDATION

— VIII —

Flight Rate. The nation's reliance on the Shuttle as its principal space launch capability created a relentless pressure on NASA to increase the flight rate. Such reliance on a single launch capability should be avoided in the future.

NASA must establish a flight rate that is consistent with its resources. A firm payload assignment policy should be established. The policy should include rigorous controls on cargo manifest changes to limit the pressures such changes exert on schedules and crew training.

NASA has formed a Flight Rate Capability Working Group to assess a safe, sustainable flight rate and to identify the constraints to this rate. The flight rate capability study will consider all required work for the standard vehicle processing flow and assure that the work is optimized in relation to the available workforce considering such factors as the manifest, nonscheduled work, in-flight anomaly resolution, mods, processing team workloads, and work balancing across shifts. The flight production study will review the requirements for mission planning, flight production development, payload assignment policy and controls and achievable software delivery capability to support flight controllers and crew training. These studies will consider the availability of the third Orbiter Processing Facility, the availability of spares, as well as the effects of supporting the Vandenberg Launch Site to determine the maximum achievable safe flight rate.

A cargo manifest policy is being formulated by NASA Headquarters which will establish manifest groundrules and impose constraints to late changes.

NASA supports increased emphasis on a mixed fleet and action to revitalize the United States expendable launch vehicle capability.

NASA Implementation of Recommendation VIII

The assessment of a safe sustainable NSTS flight rate capability was initiated in March 1986 with the establishment of a formal Flight Rate Capability Working Group. This group includes representation from Johnson Space Center, Kennedy Space Center, Marshall Space Flight Center, NASA Headquarters, Vandenberg Launch Site and Air Force Space Division.

Under the direction of this working group, flight rate capability studies are under way at Kennedy Space Center and Johnson Space Center. These studies will assess the best estimate of flight rate capability and will identify potential constraints to that rate. An integral part of the flight rate planning mechanism will be the identification and implementation of program enhancements (facilities, manpower, support equipment, procedures, production improvements) required to achieve the flight rate. The flight rate assessment will also consider flight software development and design, crew training requirements, spares provisioning, as well as maintenance and structural inspection requirements. Flight rate analyses tools and procedures that will support both accurate flight rate projection and detailed operations schedules at the Kennedy Space Center are planned. The National Research Council is conducting an assessment of the flight rate capability at the request of the Chairman of the House Subcommittee on HUD-Independent Agencies. NASA is supporting this analysis and will incorporate the results into the assessment of flight rate.

NASA has participated in Senior Interagency Group discussions on overall United State space launch strategy. NASA supports increased emphasis on a mixed fleet and actions to revitalize the United States expendable launch vehicle capabilities.

A cargo manifest policy is being formulated by NASA Headquarters which will establish manifest ground rules and impose constraints to late changes. Cargo manifest change control is being pursued through the generation of a set of manifest stability ground rules and policies which will apply to both NASA Headquarters and the program level. Proposals are being formulated at the Johnson Space Center for submission to NASA Headquarters in November 1986. In addition, manifest change impact prediction and measurement tools are being developed. Integrated scheduling and resource prediction concepts have been defined and the necessary software programming initiated.

PRESIDENTIAL COMMISSION ON THE SPACE SHUTTLE CHALLENGER ACCIDENT RECOMMENDATION

— IX —

Maintenance Safeguards. Installation, test, and maintenance procedures must be especially rigorous for Space Shuttle items designated Criticality 1. NASA should establish a system of analyzing and reporting performance trends of such items.

Maintenance procedures for such items should be specified in the Critical Items List, especially for those such as the liquid-fueled main engines, which require unstinting maintenance and overhaul.

With regard to the Orbiters, NASA should:

- Develop and execute a comprehensive maintenance inspection plan.
- Perform periodic structural inspections when scheduled and not permit them to be waived.
- Restore and support the maintenance and spare parts programs, and stop the practice of removing parts from one Orbiter to supply another.

NASA is developing an NSTS Maintenance Plan to ensure that uniform maintenance requirements are imposed by all program elements. This plan will define inspection requirements and frequency, periodic maintenance requirements and schedules, configuration control requirements and organizational responsibility, and reporting requirements. All existing test and checkout requirements documents are being reviewed and will consider the results of the ongoing Critical Items List (CIL) reviews to ensure consistency between the CIL requirements and Operations and Maintenance Instructions at the Kennedy Space Center and the Vandenburg Launch Site. NASA is actively reviewing its policy and future planning for program logistics including spare parts provisioning.

NASA Implementation of Recommendation IX

The NSTS has established a Maintenance Safeguards Team with representatives from the Johnson (JSC), Kennedy (KSC), and Marshall (MSFC) Space Flight Centers to develop a comprehensive plan for defining and implementing actions in compliance with Presidential Commission Recommendation IX. This team will serve as the focal point for all the NSTS maintenance activity and will ensure that an adequate maintenance program is in place and well understood by all elements of the program.

A National Space Transportation System Maintenance Plan is being prepared to ensure that uniform maintenance requirements are imposed by all elements of the NSTS Program. This plan will define the documentation and implementation requirements for (1) hardware inspections and schedules, (2) planned maintenance activities and schedules, (3) maintenance procedures configuration control, and (4) maintenance logistics. The plan will also define organizational responsibilities, reporting, and control requirements for NSTS maintenance activities.

Maintenance requirements for checkout, tests, inspections, servicing, and repair will be validated for both vehicle processing and depot level repair activities. The effort for the vehicle processing activity is defined and scheduled after completion of the Failure Modes and Effects Analysis/Critical Items List Review currently under way. Planning for a Depot Level Repair Requirements Review has been initiated. The Operations Maintenance Requirement Specification Document (OMRSD) which defines all test and checkout requirements is being reviewed to ensure that the requirements are complete and that the required testing is consistent with the results of the Critical Items List (CIL) review.

Maintenance procedures used by the launch sites and repair agencies are being validated by technical teams including membership from the design centers and element contractors to ensure proper implementation of requirements. Verification of Shuttle vehicle checkout and processing procedures is currently being accomplished in the Operations and Maintenance Instruction (OMI) review. An activity to establish methods to rigorously control baselined procedures for safety-related critical items and to obtain design center concurrence on any changes to these critical procedures is in place.

The problem reporting and corrective action systems presently being used by JSC, KSC, and MSFC are being consolidated and reviewed for uniformity in documentation, reporting, and trend analyses requirements based on failure and process nonconformance experience. Safety, reliability, and quality assurance activities will be an integral part of the NSTS Maintenance Program. These activities will be closely coordinated with the newly formed office of the Associate Administrator for Safety, Reliability, and Quality Assurance.

Maintenance Inspection Plans are being developed by each NSTS Project. The Space Shuttle Main Engine Project has a program approved inspection plan in place. This plan will be examined and its adequacy verified. The Orbiter Project has submitted, for program baselining, an inspection plan resulting from studies done by a major airline company. This plan establishes rigorous requirements, schedules, and a closed loop feedback mechanism for providing launch site inspection results to project personnel. Inspection plans for the External Tank and Solid Rocket Booster Projects are being developed.

The logistics program for the Orbiter vehicle has been a concern of the program since the completion of developmental flights. The lack of sufficient spare parts led to practices such as removal of parts from one Orbiter to supply another. NASA has initiated an assessment of spare parts requirements to adequately support the flight rate planning. Progress has been made with the construction of a large logistic facility at KSC in which all available parts can be stored. Additionally, the Orbiter Prime Contractor has established a Logistics Service Center near Kennedy Space Center which provides field maintenance capability for a

number of Orbiter subsystem elements. Contractual and government management changes have been made which will improve the logistics planning. Measurement criteria for monitoring the availability of spare parts are being developed and given proper attention by program management. A rigorous, closed-loop, accounting system that provides the discipline to assure compliance with all program approved check-out, tests, inspections, servicing, and repair requirements is being established.

Appendix A

March 24, 1986 Memorandum from the Associate Administrator for Space Flight:

Strategy for Safely Returning the Space Shuttle to Flight Status

National Aeronautics and
Space Administration

Washington, D.C.
20546

Reply to Attn of: M

MAR 24 1986

TO: Distribution

FROM: M/Associate Administrator for Space Flight

SUBJECT: Strategy for Safely Returning the Space Shuttle to Flight Status

This memorandum defines the comprehensive strategy and major actions that, when completed, will allow resumption of the NSTS flight schedule. NASA Headquarters (particularly the Office of Space Flight), the OSF centers, the National Space Transportation System (NSTS) program organization and its various contractors will use this guidance to proceed with the realistic, practical actions necessary to return to the NSTS flight schedule with emphasis on flight safety. This guidance is intended to direct planning for the first year of flight while putting into motion those activities required to establish a realistic and an achievable launch rate that will be safely sustainable. We intend to move as quickly as practicable to complete these actions and return to safe and effective operation of the National Space Transportation System.

Guidance for the following subjects is included:

- o ACTIONS REQUIRED PRIOR TO THE NEXT FLIGHT
- o FIRST FLIGHT/FIRST YEAR OPERATIONS
- o DEVELOPMENT OF SUSTAINABLE SAFE FLIGHT RATE

ACTIONS REQUIRED PRIOR TO THE NEXT FLIGHT:

Reassess Entire Program Management Structure and Operation

The NSTS program management philosophy, structure, reporting channels and decision-making process will be thoroughly reviewed and those changes implemented which are required to assure confidence and safety in the overall program, including the commit to launch process. Additionally, the Level I/II/III budget and management relationships will be reviewed to insure that they do not adversely affect the NSTS decision process.

Solid Rocket Motor (SRM) Joint Redesign

A dedicated SRM joint design group will be established at MSFC, with selective participation from other NASA centers and external organizations, to recommend a program plan to quantify the SRM joints problem and to accomplish the SRM joints redesign. The design must be reviewed in detail by the program to include PDR, CDR, DCR, independent analysis, DM-QM testing, and any other factors necessary to assure that the overall SRM is safe to commit to launch. The type and content of post-flight inspections for the redesigned joints and other flight components will be developed in detail, with criteria developed for commitment to the next launch as well as reusability of the specific flight hardware components.

Design Requirements Reverification

A review of the NSTS Design Requirements (Vol. 07700) will be conducted to insure that all systems design requirements are properly defined. This review will be followed by a delta DCR for all program elements to assure the individual projects are in compliance with the requirements.

Complete CIL/OMI Review

All Category 1 and 1R critical items will be subjected to a total review with a complete reapproval process implemented. Those items which are not revalidated by this review must be redesigned, certified, and qualified for flight. The review process will include a review of the OMI's, OMRSD's, and other supporting documentation which is pertinent to the test, checkout, or assembly process of the Category 1 and 1R flight hardware. KSC will continue to be responsible for all OMI's with design center concurrence required for those which affect Category 1 and 1R items. Category 2 and 3 CIL's will be reviewed for reacceptance and to verify their proper categorization.

Complete OMRSD Review

The OMRSD will be reviewed to insure that the requirements defined in it are complete and that the required testing is consistent with the results of the CIL review. Inspection/retest requirements will be modified as necessary to assure flight safety.

Launch/Abort Reassessment

The launch and launch abort rules and philosophy will be assessed to assure that the launch and flight rules, range safety systems/ operational procedures, landing aids, runway configuration and length, performance vs. TAL exposure, abort weights, runway surface, and other landing related capabilities provide an acceptable margin of safety to

the vehicle and crew. Additionally, the weather forecasting capability will be reviewed and improved where possible to allow for the most accurate reporting.

FIRST FLIGHT/FIRST YEAR OPERATIONS

First Flight

The subject of first flight mission design will require extensive review to assure that we are proceeding in an orderly, conservative, safe manner. To permit the process to begin, the following specific planning guidance applies to the first planned mission:

- o daylight KSC launch
- o conservative flight design to minimize TAL exposure
- o repeat payload (not a new payload class)
- o no waiver on landing weight
- o conservative launch/launch abort/landing weather
- o NASA-only flight crew
- o engine thrust within the experience base
- o no active ascent/entry DTO's
- o conservative mission rules
- o early, stable flight plan with supporting flight software and training load
- o daylight EDW landing (lakebed or runway 22)

First Year

The planning for the flight schedule for the first year of operation will reflect a launch rate consistent with this conservative approach. The specific number of flights to be planned for the first year will be developed as soon as possible and will consider KSC and VAFB work flow, software development, controller/crew training, etc. Changes to flight plans, ascent trajectories, manifest, etc., will be minimized in the interest of program stability. Decisions on each launch will be made after thorough review of the previous mission's SRM joint performance, all other specified critical systems performance and resolution of anomalies.

In general, the first year of operation will be maintained within the current flight experience base, and any expansion of the base, including new classes of payloads, will be approved only after very thorough safety review. Specifically, 109 percent thrust levels will not be flown until satisfactory completion of the MPT testing currently being planned, and the first use of the Filament Wound Case will not occur with the first use of 109 percent SSME thrust level. Every effort will be made to conduct the first VAFB flight on an expeditious and safe schedule which supports national security requirements.

DEVELOPMENT OF SUSTAINABLE SAFE FLIGHT RATE

The ultimate safe, sustainable flight rate, and the buildup to that rate, will be developed utilizing a "bottoms-up" approach in which all required work for the standard flow as defined in the OMRSD is identified and that work is optimized in relation to the available work force. Factors such as the manifest, nonscheduled work, in-flight anomaly resolution, mods, processing team workloads, work balancing across shifts, etc., will be considered, as well as timely mission planning, flight product development and achievable software delivery capability to support flight controllers and crew training. This development will consider the availability of the third orbiter facility, the availability of spares, as well as the effects of supporting VAFB launch site operations.

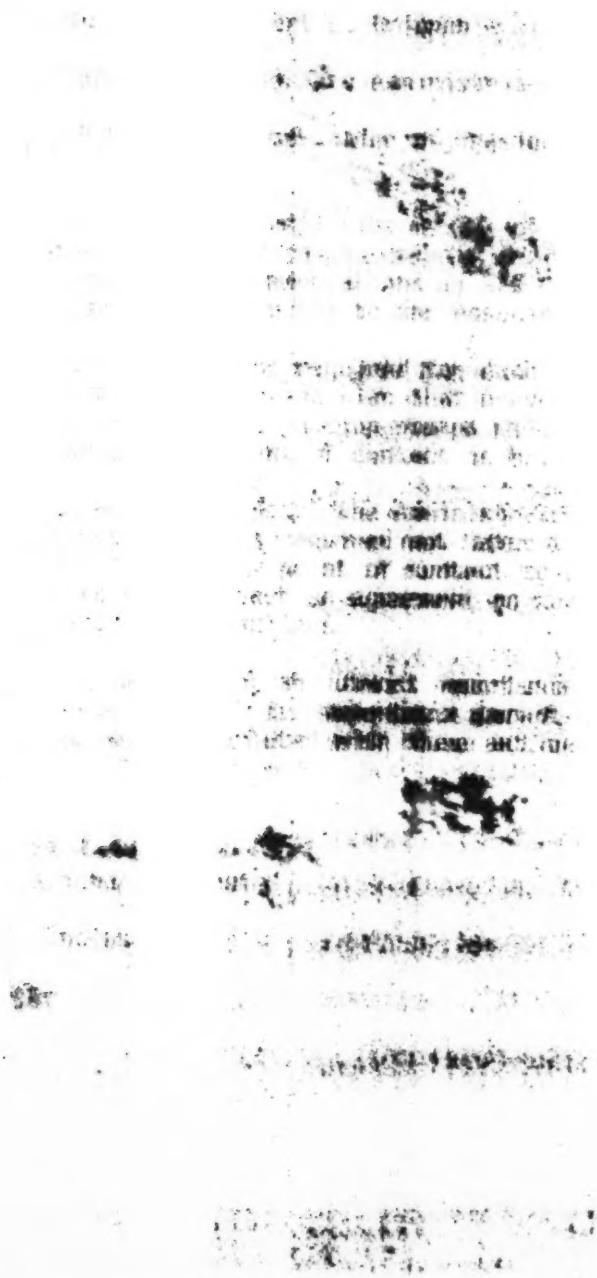
THE BOTTOM LINE

The Associate Adminstrator for Space Flight will take the action for reassessment of the NSTS program management structure. The NSTS Program Manager at Johnson Space Center is directed to initiate and coordinate all other actions required to implement this strategy for return to safe Shuttle flight.

I know that the business of space flight can never be made to be totally risk-free, but this conservative return to operations will continue our strong NASA/Industry team effort to recover from the Challenger accident. Many of these items have already been initiated at some level in our organizations, and I am fully aware of the tremendous amount of dedicated work which must be accomplished. I do know that our nation's future in space is dependent on the individuals who must carry this strategy out safely and successfully. Please give this the widest possible distribution to your people. It is they who must understand it, and they who must do it.

Richard H. Truly

NASA memoranda directing the implementation of the Presidential Commission on the Space Shuttle Accident Recommendations



NASA

National Aeronautics and
Space Administration

Washington, D.C.
20546

Office of the Administrator

JUN 20 1986

TO: M/Associate Administrator for Space Flight

FROM: A/Administrator

SUBJECT: Presidential Commission Recommendations Action Plan

The President has reviewed the report from the Commission on the Space Shuttle CHALLENGER accident and on June 13 directed NASA to undertake a program to implement its recommendations as soon as possible. The President directed me to report to him in 30 days on how and when the Commission's recommendations will be implemented. This report should include milestones by which progress in the implementations process can be measured.

The Office of the Administrator assumes responsibility for recommendation number 4 on safety organization. I have previously announced NASA's establishment of the Office of Safety, Reliability, and Quality Assurance to answer this recommendation. The Office of Space Flight is directed to take the action for all other Commission recommendations and to prepare the NASA report to the President.

I plan to report to the President on July 11, 1986. Please status me on your progress on a weekly basis.

James C. Fletcher

TELEGRAPHIC MESSAGE

NAME OF AGENCY	PRECEDENCE	SECURITY CLASSIFICATION
NASA HEADQUARTERS	ACTION: ROUTINE INFO:	UNCLASSIFIED
ACCOUNTING CLASSIFICATION: MAA	DATE PREPARED: 6/13/86	FILE
FOR INFORMATION CALL		
NAME: RICHARD H. TRULY	PHONE NUMBER: 453-1132	TYPE OF MESSAGE: ☐ SINGLE ☐ BOOK ☒ MULTIPLE ADDRESS

THIS SPACE FOR USE OF COMMUNICATION UNIT

MESSAGE TO BE TRANSMITTED (Use double spacing and all capital letters)

TO:
JOHNSON SPACE CENTER

HOUSTON, TX

ATTN: GA/MR. A. ALDRICH

ATTN: AA/MR. C. MOORE

KENNEDY SPACE CENTER

KENNEDY SPACE CENTER, FL

ATTN: CD/MR. R. SMITH

MARSHALL SPACE FLIGHT CENTER

MARSHALL SPACE FLIGHT CENTER, AL

ATTN: DA01/DR. LUCAS

NATIONAL SPACE TECHNOLOGY LABORATORIES

NSTL STATION, MS

ATTN: AA00/MR. I. HLASS

SUBJECT: PRESIDENTIAL COMMISSION RECOMMENDATIONS

PAGE NO.	NO. OF PGS.	SECURITY CLASSIFICATION
1	3	UNCLASSIFIED

STANDARD FORM 14
REVISED 11-80
GSA FPMR (41 CFR) 101-11.304

* U.S. GOVERNMENT PRINTING OFFICE : 1983 0 - 381-526 (8273)

TELEGRAPHIC MESSAGE

NAME OF AGENCY	PRECEDENCE	SECURITY CLASSIFICATION
NASA HEADQUARTERS	ACTION: ROUTINE INFO:	UNCLASSIFIED
ACCOUNTING CLASSIFICATION: MAA	DATE PREPARED: 6/13/86	POE
FOR INFORMATION CALL		
NAME: RICHARD H. TRULY	PHONE NUMBER: 453-1132	TYPE OF MESSAGE: ☐ SINGLE ☐ BOOK ☒ MULTIPLE ADDRESS

THIS SPACE FOR USE OF COMMUNICATION UNIT

MESSAGE TO BE TRANSMITTED (Use double spacing and all capital letters)

TO:

IN A MEETING TODAY BETWEEN THE PRESIDENT AND THE NASA ADMINISTRATOR, PRESIDENT REAGAN DIRECTED THAT A PROGRAM BE UNDERTAKEN TO IMPLEMENT THE PRESIDENTIAL COMMISSION RECOMMENDATIONS AS SOON AS POSSIBLE.

THE PROCEDURAL AND ORGANIZATIONAL CHANGES SUGGESTED IN THE REPORT WILL BE ESSENTIAL TO RESUMING EFFECTIVE AND EFFICIENT SPACE TRANSPORTATION SYSTEM OPERATIONS, AND WILL BE CRUCIAL IN RESTORING U.S. SPACE LAUNCH ACTIVITIES TO FULL OPERATIONAL STATUS.

NASA WILL REPORT BACK TO THE PRESIDENT IN 30 DAYS ON HOW AND WHEN THE COMMISSION RECOMMENDATIONS WILL BE IMPLEMENTED INCLUDING MILESTONES BY WHICH PROGRESS CAN BE MEASURED.

SPECIFIC DIRECTION REGARDING THOSE ACTIONS REQUIRED TO IMPLEMENT EACH COMMISSION RECOMMENDATION WILL BE FORTHCOMING WITHIN THE NEXT SEVERAL DAYS. RECOMMENDATION 4 (SAFETY ORGANIZATION) WILL BE ADDRESSED BY THE ADMINISTRATOR. RECOMMENDATION 5 (SHUTTLE MANAGEMENT STRUCTURE

PAGE NO.	NO. OF PGS.	SECURITY CLASSIFICATION
2	3	UNCLASSIFIED

NSN 7540-01-152-8161 14-105
5010-106
OMB Circular A-76 (Rev. 10-83)

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TELEGRAPHIC MESSAGE

NAME OF AGENCY	PRECEDENCE	SECURITY CLASSIFICATION
NASA HEADQUARTERS	ACTION: ROUTINE INFO:	UNCLASSIFIED
ACCOUNTING CLASSIFICATION: MAA	DATE PREPARED: 6/13/86	FILE
FOR INFORMATION CALL		
NAME: RICHARD H. TRULY	PHONE NUMBER: 453-1132	TYPE OF MESSAGE: ☐ SINGLE ☐ BOOK ☒ MULTIPLE-ADDRESS
THIS SPACE FOR USE OF COMMUNICATION UNIT		

MESSAGE TO BE TRANSMITTED *(Use double spacing and all capital letters)*

TO:

ASTRONAUTS IN MANAGEMENT, SHUTTLE SAFETY PANEL) AND RECOMMENDATION 5 (IMPROVED COMMUNICATIONS) WILL BE ADDRESSED BY LEVEL I. ALL OTHER RECOMMENDATIONS WILL BE WORKED THROUGH LEVEL II, NSTS PROGRAM MANAGER.

THE STS 51-L TASK FORCE ACTION CENTER IS HEREBY REDESIGNATED THE NSTS ACTION CENTER. I INTEND THAT THE NSTS ACTION CENTER SHALL BE USED TO COORDINATE AND TRACK THE PROGRESS OF EACH OF OUR ACTIONS AND TO BE THE NSTS POINT OF CONTACT FOR ORGANIZATIONS EXTERNAL TO THE NSTS RELATING TO THE COMMISSION REPORT.

AS PRESIDENT REAGAN STATED TODAY IN HIS LETTER TO DR. FLETCHER, "...THE MEN AND WOMEN OF NASA AND THE TASKS THEY SO ABLY PERFORM ARE ESSENTIAL TO THE NATION IF WE ARE TO RETAIN OUR LEADERSHIP IN THE PURSUIT OF TECHNOLOGICAL AND SCIENTIFIC PROGRESS." DR. FLETCHER AND I HAVE COMPLETE CONFIDENCE IN OUR ABILITY TO ORGANIZE OUR RESPONSE TO THE ROGERS COMMISSION REPORT AND TO CONTINUE OUR EFFORTS TO RETURN TO A SAFE FLIGHT STATUS.

RICHARD H. TRULY

ASSOCIATE ADMINISTRATOR
FOR SPACE FLIGHT

PAGE NO.	NO. OF PGS.	SECURITY CLASSIFICATION
3	3	UNCLASSIFIED

STANDARD FORM 14
REVISED 11-80
GSA FPMR (41 CFR) 101-35.306

Previous editions usable NSN 7540-00-634-3968

14-103

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NASA

National Aeronautics and
Space Administration

Washington, D.C.
20546

Reply to Attn of: M

TO: Johnson Space Center
Attn: GA/Manager, NSTS Office

FROM: M/Associate Administrator for Space Flight

SUBJECT: Implementation of Presidential Commission Recommendations

This direction amplifies my TWX of June 13, 1986, same subject. You are hereby assigned responsibility for the action associated with the Presidential Commission Recommendations I, III, VI, VII, VIII, and IX. In fulfilling these actions, you will be responsible directly to the Associate Administrator for Space Flight.

Specific actions required for each recommendation are enclosed. You should develop a reporting plan that provides me regular visibility into the status of all actions. Action status will be routed through the NSTS Action Center. My point of contact is Mr. J. Honeycutt, FTS 453-1261.

In order to support the Administrator's initial report to the President, your first status is required not later than July 3, 1986. Mr. D. Branscome, FTS 453-1125, is my point of contact to develop this report. Please work directly with him to reach an agreement on format and content of the portion which concerns your actions.

This work is of the utmost importance to return the U.S. safely to manned space flight. Its importance cannot be overstressed to those who accomplish the work associated with these actions.

Richard H. Truly

Enclosure

NASA

National Aeronautics and
Space Administration

Washington, D.C.
20546

Reply to Attn of: M

TO: M/Robert L. Crippen

FROM: M/Associate Administrator for Space Flight

SUBJECT: Implementation of Presidential Commission Recommendations

This direction amplifies my TWX of June 13, 1986, same subject. You are hereby assigned responsibility for the action associated with the Presidential Commission Recommendations II and V. In fulfilling these actions, you will be responsible directly to the Associate Administrator for Space Flight.

Specific actions required for each recommendation are enclosed. You should develop a reporting plan that provides me regular visibility into the status of all actions. Action status will be routed through the NSTS Action Center. My point of contact is Mr. J. Honeycutt, FTS 453-1261.

In order to support the Administrator's initial report to the President, your first status is required not later than July 3, 1986. Mr. D. Branscome, FTS 453-1125, is my point of contact to develop this report. Please work directly with him to reach an agreement on format and content of the portion which conerns your actions.

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Richard H. Truly

Enclosure

Appendix C

NASA letter to the Office of Personnel Management on revitalization of NASA through concepts contained in the President's proposed Civil Service Simplification Act

NASA

National Aeronautics and
Space Administration

Washington, D.C.
20546

Office of the Administrator

JUL 10 1986

Honorable Constance Horner
Director, Office of Personnel
Management
1900 E Street, NW
Washington, DC 20415

Dear Mrs. Horner:

We appreciate the offer you made in the June 13, 1986, meeting with Dr. Fletcher and myself to help in revitalizing NASA. The timing could not be better for us to explore jointly innovative ways to manage NASA personnel matters.

Since our initial meeting, we have taken steps to work with your office to develop an approach to implement the concepts contained in the President's proposed Civil Service Simplification Act, with the support of both the Administration and the Congress. Gaining the flexibility to better challenge and reward our personnel would greatly help NASA's effort to move forward.

We plan to work with your staff to refine these efforts and keep the project moving on a very fast track.

Your continued efforts in partnership with NASA will be vital to our success.

Sincerely,

William R. Graham

William R. Graham
Deputy Administrator